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# SEWAGE DISPOSAL

FOR

Isolated Houses and Large Inst

BY

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## SEWAGE DISPOSAL AT ISOLATED HOUSES.<sup>1</sup>

THE safe and inoffensive disposal of the sewage of buildings not within reach of a public sewer has always presented difficulties.

Until twenty years ago, the "out-of-sight-out-of-mind" system, in other words the use of cesspools, was nearly universal. The radical objections to the cesspool had already begun to be recognized, and they are now known to be absolutely condemnatory. Cesspools are always objectionable, and there are not many cases where they are at all admissible.

Soon after the introduction of the earth-closet, its inventor, Mr. Moule, devised the method of discharging sewage into shallow, underground drains, and this was soon improved and brought to something like a system by Mr. Rogers Field, who collected into a flush-tank the dribbling stream of sewage from the house and caused an intermittent discharge of considerable volume, and at considerable intervals, into the tiles. This system was somewhat improved in this country, and was brought to such a state of efficiency as to come into quite general use. Among other large works of this kind may be mentioned those planned by the writer for the disposal of the sewage of the Woman's Prison at Sherborn, Mass., and of the village of Lenox, Mass. Somewhat later Mr. Croes used the same system, discharging his tank by intermittent pumping, instead of the intermittent action of an automatic siphon, at the Lawrenceville School in New Jersey. For domestic use in connection with suburban houses, the system has been very widely adopted. In 1884, the writer used a flush-tank for the accumulation of the sewage from a large country house near Baltimore, delivering its discharge with satisfactory results directly onto the surface of the ground, instead of into sub-surface absorption-tiles.

Up to about 1890, the theory of sewage disposal was a matter of development and interest rather than of positive knowledge.

The experiments carried on under the auspices of the Massachusetts Board of Health at its experimental-station at Lawrence, Mass., under the immediate and admirable direction of Mr. Hiram F. Mills, an engineer of great capacity and a member of the Board, have given us much more exact knowledge on the subject than we had before. It is not too much to say that these experiments and Mr. Mills's deductions from them constitute the most important advance yet made within so short a time in the world's sanitary knowledge. The voluminous publication of the details of these experiments, and the conclusive reasoning based upon them, will well repay the careful study of all who are interested in the subject. For our immediate purpose, it is sufficient to say that these experiments demonstrate beyond question the fact that, and almost the precise manner in which, organic matter contained in sewage is reduced to its elements; that is, is absolutely destroyed as organic matter. The experiments were conducted in tanks filled with various filtering materials. The simplest and most striking illustration of the process was obtained in the case of a tank "filled with gravel-stones, none of which would go through a screen having a mesh one-eighth of an inch square, but all of which would go through one having a mesh three-eighths of an inch square"; and another "filled

with gravel, none of the stones of which were less than three-fourths of an inch in diameter, nor more than  $1\frac{1}{4}$  inches." In both cases the gravel was carefully washed, so that no sand or soil would remain attached to the stones. The material was put into the tanks damp from washing. In his "General View of Results", Mr. Mills says:

"The experiments with gravel-stones gives us the best illustration of the essential character of intermittent filtration of sewage. In these, without straining the sewage sufficiently to remove even the coarser suspended particles, the slow movement of the liquid in thin films over the surface of the stones, with air in contact, caused to be removed for some months 97 per cent of the organic nitrogenous matter, a large part of which was in solution, as well as 99 per cent of the bacteria, which were, of course, in suspension, and enabled these organic matters to be oxidized or burned, so that there remained in the effluent but three per cent of the decomposable organic matter of the sewage, the remainder being converted into harmless mineral matter.

"The mechanical separation of any part of the sewage by straining through sand is but an incident, which, under some conditions, favorably modifies the result; but the essential conditions are very slow motion of very thin films of liquid over the surface of particles having spaces between them sufficient to allow air to be continually in contact with the films of liquid.

"With these conditions, it is essential that certain bacteria should be present to aid in the process of nitrification. These, we have found, come in the sewage at all times of the year, and the conditions just mentioned appear to be most favorable for their efficient action, and at the same time most destructive to them and to all kinds of bacteria that are in the sewage."

We see, therefore, that the process that is called "filtration" is not filtration, but a mere exposure of the sewage to the air under conditions favorable to the development of the destructive bacteria, which, so far as we now know, are the sole agents for the purification of sewage by the complete oxidation of its organic impurities. The value of these experiments is not confined to their relation to the process known as intermittent downward filtration. They seem to point out the method of destruction by all natural processes of oxidation, whether in filtration through aerated material, by exposure on and in the immediate surface soil, and mixture with oxygenated waters, as in flowing streams. Indeed, it is questionable whether intermittent downward filtration will be much used in its integrity, save under exceptional conditions. This is a system which precludes the possibility of agricultural returns, and it requires for its perfect action soils of such a highly porous character as are by no means generally found where sewage is to be disposed of. These experiments, however, mark out clearly the character of the processes of destruction and the conditions required for efficient oxidation.

When sewage is delivered into porous absorption-drains laid in the surface soils, it soaks away into ground which is sufficiently penetrated by air to facilitate bacterial growth. When sewage is delivered over the surface of the ground the process is substantially the same, but exposure to the air is more complete, and oxidation is,

<sup>1</sup> From the *American Architect* for March 12, 1892.

within suitable ranges of temperature, proportionately active. In all work of sewage-disposal, the conditions essential to bacterial oxidation must be kept constantly in mind, and as much as possible favored. The process being in all cases the same, the skill and judgment of the engineer will be applied to regulating the work in such a manner as to secure their best development and most favorable action.

Aside from the efficiency of the ultimate disposal, it is of the greatest importance when the works are established in the immediate vicinity of the buildings in which the sewage is produced, that all parts of the process should be free from offence to the eye and to the nostril. The system of sub-surface irrigation, with the use of a double-chambered flush-tank, the first chamber holding back solid matters and scum, and the second chamber accumulating and intermittently discharging the liquid portions, has always had the drawback, perhaps more theoretical than practical, that the first chamber had, necessarily, some of the worst characteristics of a cesspool, for, while the free movement of liquid through it prevents a high degree of foul putrefaction of any of its liquid portions, and indeed carries off the gases of the putrefying sediment, the scum with which the contents of the tank are always covered is in a constant state of decomposition, and is constantly producing foul and objectionable vapors. No way has yet been discovered in which this foul deposit-chamber can be dispensed with in the case of sub-surface disposal with the small-sized absorption-drains generally used. As this is the system now usually adopted, and as it is still the best one available under certain conditions, its details are shown in the accompanying diagrams (see Illustrations). Figure 1 shows the construction of the double-chamber tank. The settling-chamber, *A*, is a small round cistern with a wide throat—not less than eighteen inches diameter—to facilitate the removal of its scum and deposit. It receives sewage from a pipe turned down through the dome and barely trapped against the return of air—if deeply trapped, grease

accumulates and obstructs the drain; with this slight trap, the flow from an ordinary house suffices to keep it free. It overflows through a deeply-trapped pipe into the discharging-chamber, *D*. It is divided by a wall into two chambers; the top of the wall being just at the overflow line. The compartment, *B*, on the inlet side, has its water considerably agitated by the inflow. Before the dividing-wall was adopted, this agitation was communicated to the contents of the whole chamber, and flocculent matters, which would settle to the bottom or float to the top in still water, were carried over by the current into the discharging-chamber. This agitation is now confined to the compartment *B*, from which the liquid portion flows to the compartment *C* in a thin sheet over the top of the wall, in such a manner as not to disturb the contents of this second compartment, allowing flocculent solids to settle quietly to its bottom. Under some circumstances, perhaps due to a higher temperature in the sewage, and this to its larger amount, the decomposition of the sediment and of the scum is sufficiently active to prevent accumulation to an injurious amount. In such cases, the settling-chamber need never be cleaned. This is not to be depended upon without occasional inspection. In the majority of cases it is necessary every few months to bail out the chamber and get rid of its accumulations, which should be buried or dug into the ground at once.

The liquid overflow from the settling-chamber *A* to the discharging-chamber *D* represents practically the full amount of sewage brought down by the drain. The discharging-chamber should be made large enough to hold the product of at least twelve hours; there is no objection to its retaining twenty-four-hours' supply—a longer retention would lead to too much putrefaction. This chamber is furnished with an automatic siphon. The one shown being what is known as the Rhoads-Williams siphon. Its details are shown in Figure 2.

It depends for its action on the sudden releasing of compressed air contained between the inflow from the tank and the deep trap near the outlet. When the pressure is sufficient to force the water in the blow-off trap, *a, a*, to the bottom of this trap, the air-pressure is released, and the head of water, which it had held in the tank, forces a full flow into the siphon and brings it rapidly into action. Air is introduced for the breaking of the siphon after the main flow has ceased by the admission of air from the drain through the pipe, *b b*. These siphons are sold by flush-tank dealers.

The siphon is located entirely outside of the tank in the ground. This obviates the serious fouling of the siphon itself, which has always been a source of difficulty when it was placed inside the tank. Its opening into the tank is funnel-shaped so as to take the flow rapidly and to make sure that there will be no obstruction from such minor solid matters as the sewage may contain. It is not ordinarily found necessary to clean out the discharging-chamber, matters which

would otherwise accumulate within it being held back in the settling-chamber.

Its outflow is a slightly putrid sewage containing more or less fine flocculent matter, not enough to interfere with the proper action of two-inch absorption-drains. These absorption-drains may be placed at a greater or less distance from the tank as the tank may be at a greater or less distance from the house. They are made of ordinary round two-inch tile in one-foot lengths, laid in earthenware gutters, their joints being open about one-fourth inch and being protected against the

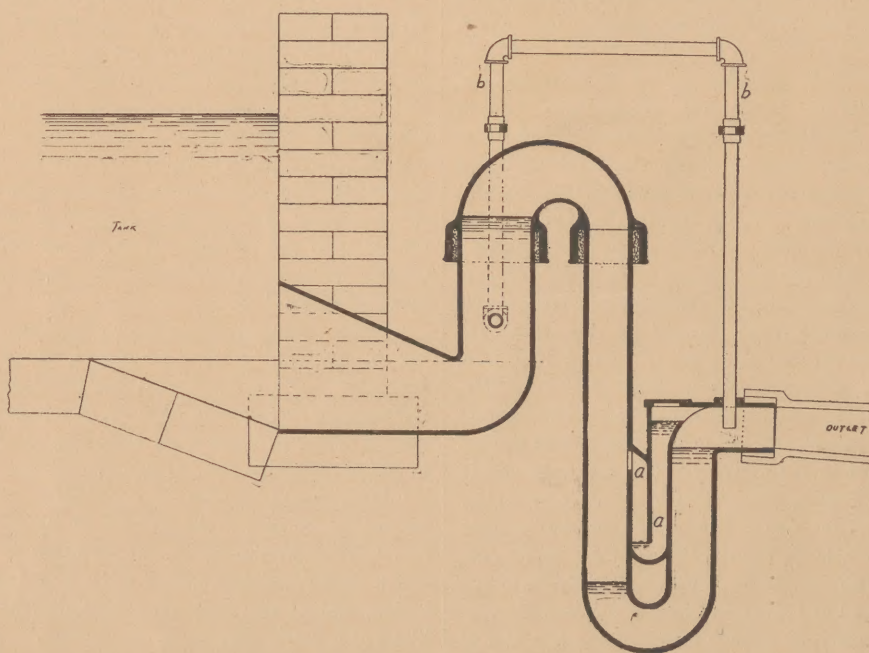


Fig. 2. The Rhoads-Williams Siphon.

entrance of earth by the loose-fitting cap laid on the top. The gutters and caps are of larger radius than the outside of the tile, so that practically the whole joint is available for the escape of sewage into the ground. The surface of the gutter on which the tile is laid should be ten inches below the finished surface of the ground. In a reasonably porous surface loam, it will suffice to have one foot of tile for each gallon of the contents of the discharging-chamber. The tile, caps and gutters are shown in Figure 17.

If the soil is heavier, the length must be increased. An impervious clay is not well suited, under any circumstances, for this use, but where nothing else is available there should be at least three feet of tile per gallon. The tile may be one continuous line, or a number of shorter lines, connected with the four-inch main leading from the flush-tank. The tiles need not be more than three feet apart, though twice this distance is not unusual. In fact, the system is in this respect a very flexible one and can be adapted to land of any shape or inclination. The fall of the main line from the tank to the absorption-drains should not, especially after coming within twenty feet of the first line of tiles, have a fall of more than four inches to one hundred feet. Its joints should be cemented and the branches for connection with the tile lines should come out from the bottom of the tile, not from the middle as is usual with its vitrified branches. Special pieces for this purpose are to be obtained from the dealers. The

absorption-lines themselves should have a fall of not more than two inches per one hundred feet: more than this gives a tendency to an accumulation of sewage at the far end of the line, and, if the line is long, to a breaking out of the sewage at the surface.

Figures 3, 4 and 5 show three different methods of applying this system according to variations of the ground. In each case the dotted lines are contour-lines showing differences of elevation of one foot.

In Figure 3, the flush-tank *A* receives its sewage from the sink-drain leading from a corner of the house. Its discharge is through a direct line to the point *c*, starting at the tank at a depth of three or four feet below the surface and coming to within a foot of the surface at the point *c*. At the point *c* the main drain is turned at an angle and has three different outlets to be used, one at a time, in alternation. The first one communicates with two parallel drains at the bottom of the field these having a sufficient combined length to receive the whole discharge of the tank. The second one runs parallel to the first, to two absorption-drains corresponding with the first two. The third communicates with the other system of three parallel lines which are shorter, having about the same aggregate length as the two of the other systems. They are carried around nearly parallel to the contours to secure the requisite slight fall.

In Figure 4 the flush-tank is fed by two drains from the house and connects, as shown, with three series of three drains each. The land is much more nearly level and the nine absorption-drains are in ground having a total fall of only one foot.

In Figure 5 the flush-tank is fed by a single drain, not straight, and connects with its alternating chambers. There are two series of drains, four on one side of the field and four on another, while a third line connects with the series of three shorter drains on each side of the medial line.

The flush-tank may be placed in any position and at any distance from the house and the field may be at any distance from the flush-tank to which a proper fall can be obtained.

One modification of this system which will obviate much of the difficulty by requiring a greatly reduced retention of solid matters, where indeed a coarse screen may be made to hold back all that it is necessary to retain, consists in the use of larger absorption-tiles, say four inch or six inch, with open joints, laid just under the surface of the ground and laid in two, or better, three series, each of which has sufficient capacity in its pipes to receive the entire contents of the tank at each discharge. The discharge being at intervals of from twelve to twenty-four hours, the liquid sewage with its soluble and its finer suspended impurities will have ample time to leak out into the soil; and during the period of intermission, while the other two series of drains are being used, worms, beetles and other insects will consume, or decomposition will destroy, the relatively small amount of deposited matter, which, however, might be sufficient to obstruct two-inch tiles.

A still further modification consists in making the drains of similar large tiles of "horseshoe" shape, laid in a trench filled with coarse gravel or broken stones. The capacity of the tiles and of the voids among the stones in each series should be sufficient to receive the full contents of the tank. Where the ground is reasonably absorptive, and is sufficient in quantity, the large tiles alone may be used. Where the ground is less absorptive and is restricted in area the coarse matters surrounding the tiles will be a decided advantage.

Cross-sections of four-inch horseshoe-tiles laid in trenches filled with stone or gravel are shown in Figures 11 and 12 and 13.

In Figure 11, the ground is supposed to be reasonably absorptive, like garden mould. In Figure 12, the natural soil is very heavy and non-absorptive, and is level or nearly so. It is thoroughly underdrained and is covered with sand or gravel in low ridges, being deeper at the absorption-drains than midway between them. The purification takes place entirely in this porous and well-aerated surface, the clarified water sinking into the drained ground below. In Figure 13, the land is non-absorptive and has a decided slope. It should be well underdrained with tiles running up and down the slope. The surface is covered with sand or gravel and is divided into sections by banks of clay (under the sand) at the foot of each section. The sewage is delivered into a horseshoe-tile, with broken stone, at the upper side of each section and is purified (and its water is absorbed) before it reaches the clay bank below, or is held by this bank until it is disposed of.

This question is often raised with reference to the sub-surface system: "If the dire results of the use of the ordinary leaching cess-pool are so serious, why is it not just as bad to discharge the same materials into the ground by leaching drains?" The difference is radical. In the case of the cesspool, the leaching takes place almost entirely at such a considerable distance from the surface that the exclusion of air makes bacterial action impossible, while the delivery through drains laid immediately under the sod is into aerated ground which is teeming with bacteria.

In the system described above, a certain amount of putrefaction is inevitable and putrefaction is always objectionable. When once its fecal matter is submerged, so as to prevent the exhalation of its odors into the atmosphere, *fresh* sewage is entirely inoffensive to the smell. It is simply so much dirty water. It might be thrown in considerable quantities on to a grass plat without other objection than that which would attach to the sight of its solid portions. Unless thrown so frequently and in such quantities on the same spot as to saturate the ground, exclude the air, and so prevent bacterial action, it would produce no odor whatever, barring the slight odor of exposed fæces. The same sewage retained for two or three days in a barrel, vault, or pool, would enter into a state of offensive decomposition and would constitute a nuisance of a serious character.

The real problem in the disposal of household sewage, and indeed of the sewage of large institutions, and even of small towns, is to bring it into contact with a suitable oxidizing medium, while in so fresh a condition as not to be offensive and to make sure that the drains and other appliances through which it passes shall at no time become offensive. Offensive odor is, of course, chiefly to be guarded against, but offence to the sight would also constitute an important objection. No method has as yet been devised by which the whole process could be appropriately carried on on the front lawn of a dwelling-house. We have, however, arrived at a point where even in a reasonably secluded back-yard, all of the conditions may be satisfied. Setting aside exceptional cases, where only the sub-surface system with a double chambered flush-tank would be acceptable, the work may be done in a great majority of cases by a system of surface disposal or of sub-surface disposal with large pipes with an automatic flush-tank from which the deposit-chamber is absent, which may at all times be thoroughly aerated and which may be cleansed with sufficient frequency to prevent odor from its sliming. Especially in connection with such a flush-tank can the ventilation of the main drain and soil-pipes be maintained with such completeness as to prevent the accumulation of odors in them. The objection to placing a flush-tank of this character quite near to a house is rather fancied than real.

The nearer it is and the more constantly subjected to inspection, the greater will be the certainty of keeping it always in good condition. On the other hand, the farther from the house, the more will the solid parts of the sewage be broken up in transit, the less imperative will be the need for scrupulous cleanliness, and the less the care required. However, civilized living requires great care in all such matters. Civilization is only lately beginning to take cognizance of this requirement, and the public at large is still disposed to like best a system which calls no attention to itself and of which the objectionable features are so hidden as to be easily forgotten. Even under their best development, such systems belong to the "out-of-sight-out-of-mind" class.

Until 1879, when the writer constructed for the late E. F. Bowditch, of Framingham, Mass., a water-closet consisting of a white earthenware hopper set in white tiles with nothing in front of it, and with only a seat without a cover over it, this seat being hinged to turn back and expose the hopper, it was the universal rule, in housework, to convert the water-closet into an unobtrusive piece of furniture by enclosing it tightly in wood-work—often handsome cabinet-work—with a lid attempting to conceal its character. Now, a dozen years later, all "first-class" plumbing supplies only such fully exposed closets, frankly showing what they are and demanding, and receiving, the constant care which removes the least suggestion of offensiveness or indecency. The modern closet so constructed, is in every respect unobjectionable; the old closet depending on concealment for its decency, was almost universally indecent. It manifests itself, not to the sight, which soon becomes accustomed to whatever is needful and appropriate, but to the smell which never becomes

accustomed to the fetid odor of a highly ornamental pan-closet, even though built around with polished rose-wood.

Unquestionably, the same principle will apply in the case of apparatus for the disposal of sewage outside of the house. The cess-pool, the vault and the double chambered flush-tank will soon have become a thing of the past, among those who care for good sanitary conditions. Their places will be taken by some device having the essential features of the system described below, combining efficiency with the possibility of, and the demand for, perfect cleanliness. This being accomplished, the "horrid drains" will soon cease to exist, or to be thought about.

It is not to be supposed that this precise manner of applying the system will long remain the accepted one. But the principle of the arrangement seems to embody all the elements of permanence. This principle may be thus stated:

Deliver the sewage as soon as produced, through thoroughly ventilated pipes and drains, to a point outside of the house; hold back its coarser substances by some form of screen which will allow everything to pass that can, in an unobjectionable way, be disposed of with the sewage; accumulate the regular flow through the drain in a receptacle large enough to hold the supply of a few hours, or of a day, as the case may be; the receptacle becoming full, discharge its contents automatically, rapidly and completely on to the surface of the ground, or into drains immediately below the surface, for its final, complete and inoffensive disposal; arrange the screen and tank in such a way that they may be kept in a cleanly condition with little labor and without requiring the constant supervision and nagging of the master of the house. The appliances shown in the Figures 6 to 16 and the method of working described in connection therewith, seem to constitute a satisfactory application of this principle.

Figure 6 shows a vertical, longitudinal section, Figure 7 a plan, and Figure 8 a vertical cross-section of a new form of flush-tank of which the inside measurements are, a width of one foot eight inches, a length of six feet and a height of two feet. At a distance of four inches below the top on the long sides, a ledge two inches wide is formed by setting the brickwork of the walls that far back.

This ledge is intended to receive wire-cloth screens twenty-four inches square, shown in Figure 10. The length of the tank may be increased to any number of multiples of two feet in order to obtain the desired capacity. A tank eight feet long would take four screens, a tank ten feet long, five screens, etc. The uniform width is maintained as the screens are made only in the one size and as they would be liable to sag if much wider between their supports. The bottom of the tank is so graded as to deliver its contents entirely at the centre of the discharging end where there is a depression equal to the receiving height of the throat of the siphon at its narrowest part. At the upper or inflow end of the tank there is built a recess fifteen inches square to receive the screening cage shown in Figure 9. This cage is made of galvanized-iron-wire cloth with one-inch mesh. It is entirely closed at the top and bottom and on three of its sides, that which is to be placed next to the inflowing drain, has an opening at its top ten inches square. This cage constitutes a complete screen to withhold whatever will not pass a one-inch mesh—paper and all solids of considerable size. The agitation of its contents by the inflow will break up much of the softer solid contents of the sewage and carry them through the meshes; what will not so pass must be retained because it would tend to obstruct pipes in the case of sub-surface delivery and would make objectionable deposits on the ground in the case of surface delivery. These cages are furnished in duplicate, so that whenever one is removed for cleaning, another can be substituted for it immediately. The one removed, after standing a few minutes, will have parted with all of its liquids and its solid contents can be shaken out through the ten-inch opening and removed, or dug into the ground. When the cage and the covers, Figures 9 and 10, are all in place, the whole tank is sufficiently screened from observation and is protected against leaves and rubbish which might otherwise get access to its contents. As often as experience shows it to be necessary, perhaps daily, the covering screens, Figure 10, should be removed, after discharging the tank, and its walls and bottom should be thoroughly swept down, the sewage accumulated in its outlet being sufficient for such washing. As above indicated, the frequency with which this cleansing should be performed will depend on nearness to, or remoteness from, the house, walks, etc.

Figure 18 shows the masonry construction of this tank, the material being brick glazed on the inner face and marble or other slabs at the top.

The tank is discharged after its contents reach a certain height by the action of a Rhoads-Williams automatic siphon placed entirely outside of the tank, having a funnel-shaped inlet for the entrance of the sewage. This siphon will require no attention. Whenever the tank fills to the discharging line, the whole accumulation will flow out rapidly and when the flow ceases, the siphon will "break," allowing no further discharge until the tank has filled again.

The tanks may be built of ordinary brickwork laid and coated inside and out with Portland cement or with stone or concrete similarly coated. They may be cheaply but simply made or they may even be lined and capped with white marble. Another excellent material would be white or straw-colored glazed bricks laid with close joints. Elegance of finish will not be altogether useless, for the finer they are the more easily and the more certainly will these tanks be kept in good condition.

Figure 14 shows the flush-tank illustrated in Figures 6 to 10, placed at some distance from the house, receiving sewage from three house-drains, and delivering its contents for surface disposal by the use of three alternating systems of surface gutters or barriers to equalize the flow. These sections are marked *A*, *B* and *C*, the gate-chambers *a*, *b* and *c* regulating the distribution. In *A* and *B* the sewage is delivered along the upper edge of gently sloping land. If the land is steeper, the gutters or barriers must be nearer together to equalize the flow. Water escaping from the upper gutter or barrier 1 is collected again at barrier 2, and again at barrier 3. Disposal for section *B* operates in the same manner. On section *C*, the gutters or barriers being much longer, only two are needed. These illustrations are not drawn to scale, and are only intended to illustrate the general features of the process. The gutters or barriers must be absolutely horizontal, and so arranged that the sewage escaping from them will flow evenly over the land below. The distribution may require the cutting of a leader-furrow here and there in the grass with a spade.

This method of surface irrigation removes absolutely all impurity from the sewage; what becomes of it after it has passed over a sufficient area of ground is immaterial. If it escapes into the brook or other water-course, it will by that time have become purer than the water of the brook itself.

Figure 15 shows a system in which the same tank is used, receiving the flow from four house-drains, and delivering its sewage into absolutely level, wide trenches of sufficient length. In the case shown, there are two of these trenches returned on themselves to give sufficient length. They are marked *a*, *a*, *a* and *b*, *b*, *b*. In connection with the same system, there is shown a system of surface irrigation on sloping land. The satisfactory use of the trenches *a*, *a*, *a*, and *b*, *b*, *b*, requires land of very absorptive character, the more porous the better. The best of all is a fine gravel. As the trenches become filled on the discharge of the flush-tank, the liquid soaking away into the ground, there is left a felt-like coating on the surface, which requires either a sufficient intermission of use to be destroyed by exposure to the air, or which accomplishes the same purpose, a thorough raking of the surface from time to time into the material in which the trenches are cut.

Figure 16 shows the same flush-tank surrounded by a screen of evergreens, *s*, *s*; two systems of sub-surface absorption-drains similar to those shown in Figures 3, 4 and 5; and one system of surface disposal, similar to those shown in Figure 14.

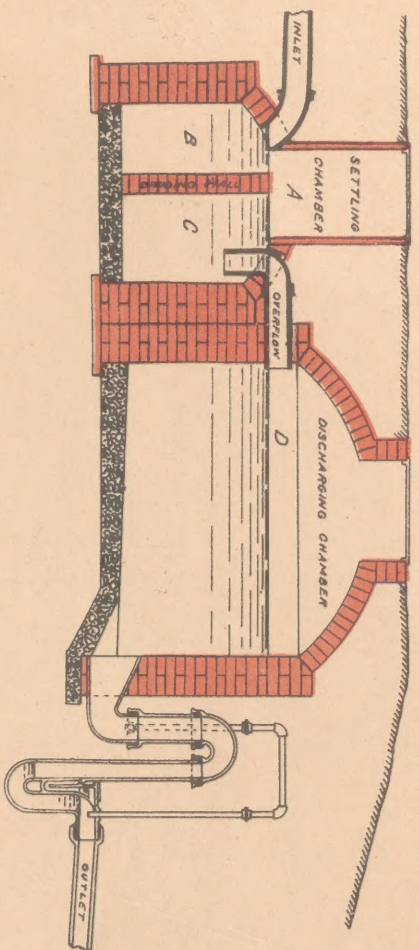
The variation of details, such as the size and location of the flush-tank, the arrangement, location and extent of the surface gutters or barriers, the horizontal trenches, the sub-surface absorption-drains, etc., may be almost infinite, so that the character of the soil, the formation of the surface, the use to which the land is to be put, the necessity for concealment, etc., may be accommodated in all cases.

It may with advantage be repeated here that while this system of disposal seems to be as nearly perfect as is possible in the present state of the art, no such system will withstand neglect. It affords a perfect solution of one of the most difficult and dangerous problems connected with life in districts where sewers are not available, and the completeness of the result to be secured amply compensates for the slight amount of regular attention required.





Fig. 1



# DETAILS OF SUB-SURFACE IRRIGATION

DEvised BY GEORGE E. WARING, JR.

Fig. 17

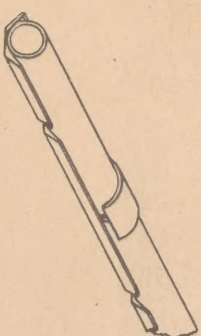


Fig. 18

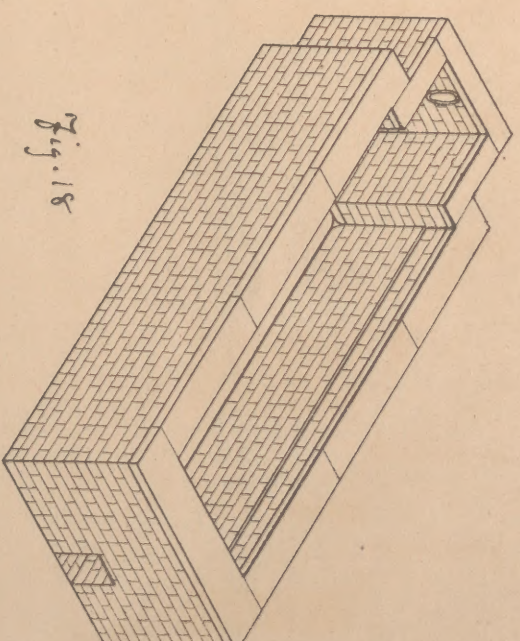


Fig. 3

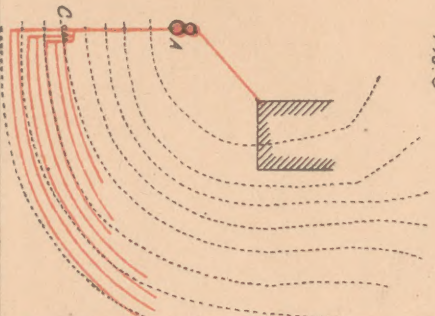


Fig. 4

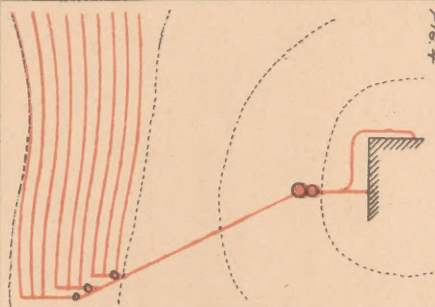


Fig. 5

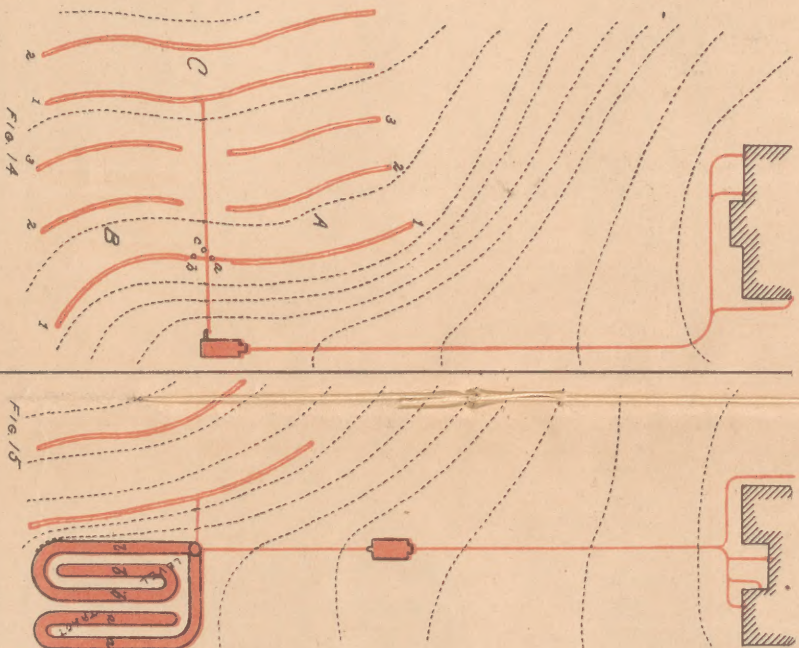
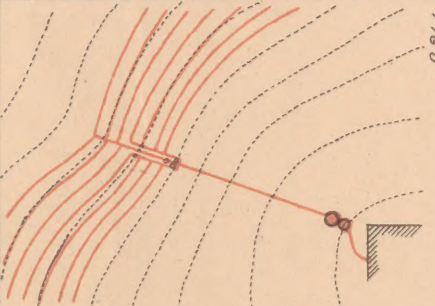


Fig. 12

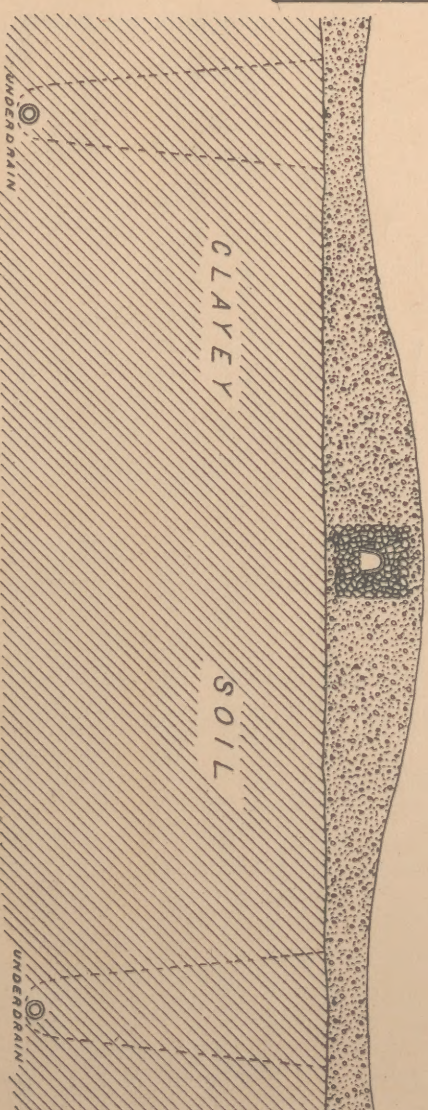


Fig. 13

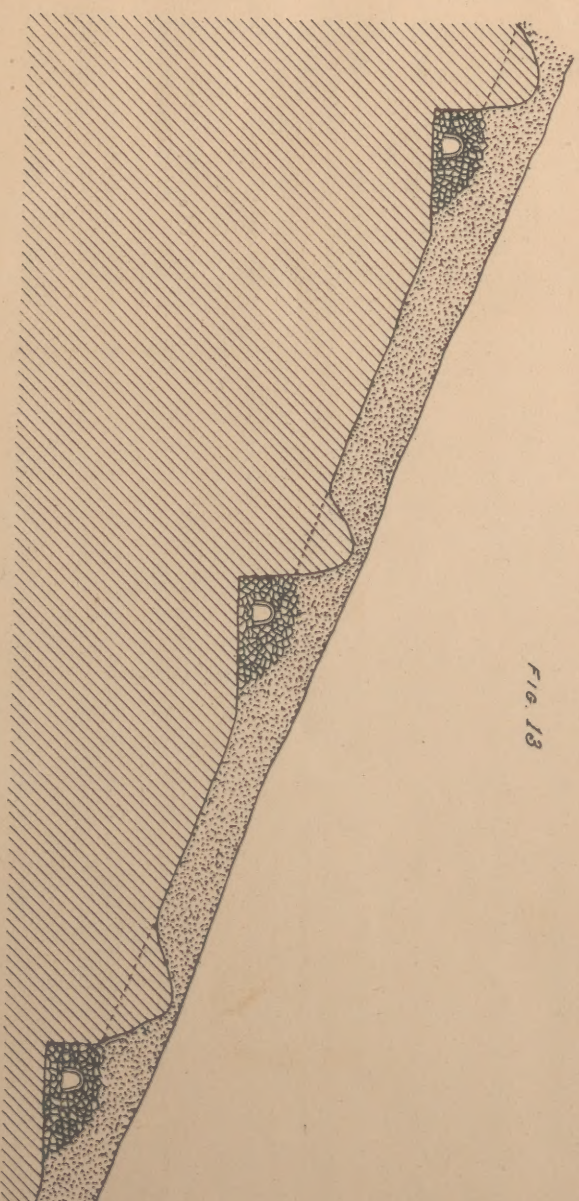
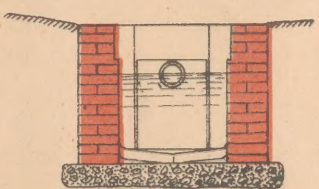


Fig. 7



SECTION A-B  
FIG. 8

Fig. 6

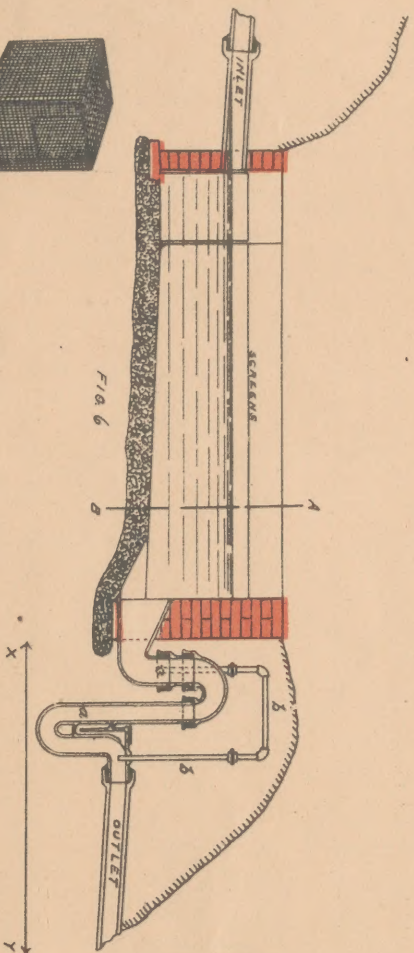
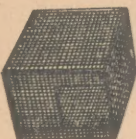


Fig. 10



Fig. 9



x

y

Fig. 16

Fig. 16



# DISPOSAL OF SEWAGE AT LARGE INSTITUTIONS.<sup>1</sup>

THE disposal of sewage at insane asylums, prisons, schools and hotels by irrigation or land-filtration, although not as yet very generally adopted in this country, has had sufficient use to demonstrate its entire efficiency and its superiority in all cases where the surrounding conditions are suitable. It is the most promising means for solving the very difficult problem which the gathering of a large number of persons in buildings beyond the reach of sewers always presents.

It must be more than ten years since the adoption of surface-irrigation for the disposal of the sewage of the Insane Asylum near Worcester, Mass. There most of the sewage is delivered at a considerable distance from the building and on gravelly land, but the arrangements include the necessary pipes and pumping facilities for irrigating the ground immediately in front of the administration building, where sewage, in its fresh state, is spread directly over the surface of a large, sloping lawn immediately adjoining the main-entrance drive, and within a very short distance of the windows of rooms occupied by both officers and patients. The disposal on both tracts seems to be without offence and entirely effective. The sentimental objection to such delivery of sewage on pleasure-ground almost adjoining the building would seem to be very great, but there is only the sentimental objection. Practically, all that is necessary is to screen out from the sewage paper and other matters which would show on the surface of the lawn. What remains to be delivered contains often less, and rarely more, than one part in two hundred of anything but pure water. Such a very dilute mixture may be treated practically as ordinary brook-water might be treated up to the time when it enters into a state of putrefaction, from which, and not from foreign substances as such, the real source of offence arises.

This point cannot be too strongly insisted upon. It constitutes the key-note of all successful sewage-disposal. Before putrefaction begins sewage has no offensive odor; after it begins to putrefy, it rapidly becomes both offensive and dangerous. Therefore, no system of surface-disposal can be entirely satisfactory from which the element of putrefaction is not eliminated. Even such small receptacles for retaining sewage as ordinary kitchen grease-traps, large catch-basins, cesspools and all possible seats of putrefaction should be regarded as objectionable in any system of house drainage or sewerage of which the outflow is to be treated by surface irrigation or filtration.

In the competition for the location of the Eastern Insane Asylum of Pennsylvania, the city of Norristown made a very strong and successful argument, based on the exceptionally good drainage facilities offered by a small stream, Stony Creek, flowing by the proposed site and through the city to the Schuylkill River. Soon after the occupation of the Asylum, a loud outcry was raised against the intolerable fouling of Stony Creek, and the writer was engaged to devise means for artificial removal. The details of the system adopted have already been extensively illustrated and described.

The sewage is received in an open reservoir 40 feet square and 7

feet deep. When this reservoir becomes filled, it is discharged by the operation of an automatic siphon. Toward the end of the discharge the walls of the reservoir are washed down by an automatic sprinkling pipe, and its floor is frequently washed with a hose. The outflow, amounting to about 75,000 gallons, is delivered through an 8-inch pipe which passes through a valley under a creek, and rises about 15 feet to a carrier running along the far side of the irrigation-field, from which it is delivered alternately over each of three sections into which the field is divided, several discharges being applied in succession to each section. The tank discharges three or four times in twenty-four hours. This system was first put in operation June, 1885. In June, 1887, the President of the Board of Trustees wrote:

"Since your system was put into operation at the hospital, every doubt has given place to a conviction that the problem of sewerage for public institutions has been successfully solved. It has been a success from the first and the Board of Trustees and the public are entirely satisfied with the results."

Up to the last accounts, 1889, the system was performing its work in a most satisfactory manner.

In 1889, the writer was engaged to provide for the disposal of the sewage of the Insane Asylum near London, Canada. The work involved the reconstruction of much of the plumbing-work of the establishment and the entire abandonment of the old system of outside drainage, which had been through combined sewers taking the roof-water and foul sewage of all the buildings to the head waters of a brook which passes through the city. To satisfy complaints that had been made as to the fouling of the brook, a rude sort of settling-basin had been established to hold back solid matters. This failed to correct the difficulty. In arranging the new work, this old system was left for the removal of roof and ground water only. The general arrangement of the improvement is shown on the full-page illustrations.

All of the buildings have their soil-pipes, kitchen-drains, laundry-wastes, etc., connected with a system of 6-inch sewers having tightly cemented joints and with carefully graded inclinations, leading to a central tank. Each branch of these sewers is provided at its head with an automatic flush-tank, preventing deposits in the sewers, and so preventing putrefaction. The central tank is 70 feet by 40 feet; its walls are 16 inches thick; its bottom is of concrete. It is covered by three longitudinal arches, 12.66 feet span, 12 inches thick. These arches rest on two longitudinal walls with arched openings. The floor of the tank is graded as shown, varying between elevation 31.9 and 32.3 respectively. Each section has a longitudinal drainage-gutter, with its upper end at 32.22 and its lower end at 31.98, 31.94, 31.90, with a cross gutter leading to a sump four feet in diameter with its bottom at grade 30.0. The bottom of this sump is hemispherical, and the suction of the pump is centrally located, having six inches space between its mouth and the bottom. This mouth should be bell-shaped, not straight as shown in the drawing. The elevation of the ground at this point is 47.5, making the surface of the floor of the tank about 15 feet below

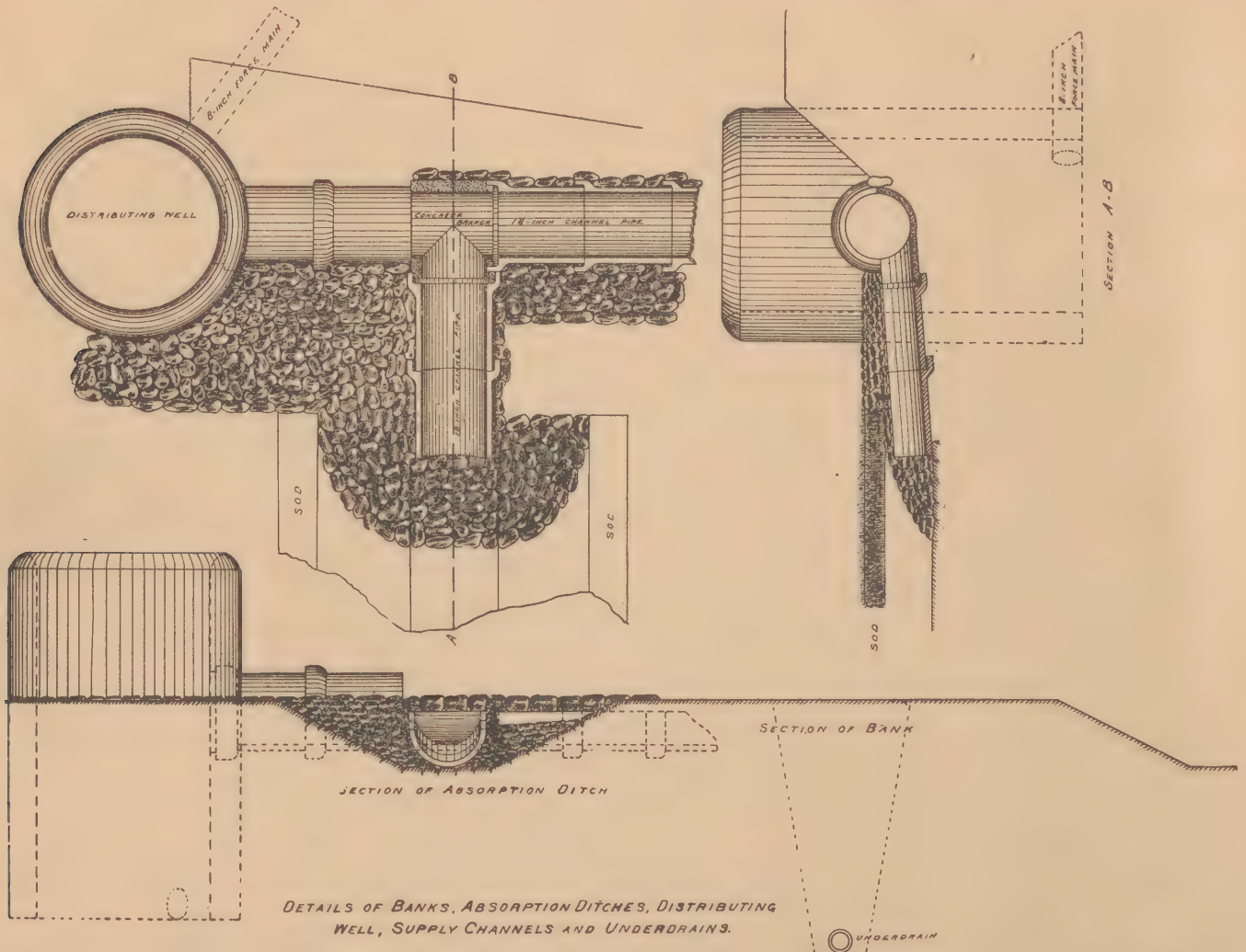
<sup>1</sup> From the *American Architect* for April 9, 1892.

the surface. There are three man-holes at each end of the tank, with covers at the surface of the ground. At the receiving end of the tank, at the head of the central chamber, is a screening-chamber, reaching to the surface of the ground and with its bottom at elevation 34.4. The opening from this chamber into the tank is 8.33 feet wide, and it is provided with a screen carried in slots in the side walls 4.5 feet high in the centre. The screen is made of wrought-iron and galvanized. The vertical bars are of half-inch round iron, and the openings between them one inch wide. The top of this screening-chamber is covered at the surface of the ground with a hinged wooden cover.

The tank is intended to be filled to a depth of 5 feet or to the spring of the arches, to which height it has a capacity of a little more than 100,000 gallons. It is located near the main fire-stack of the establishment, adjoining which a basement pump house has been constructed, having its floor at such an elevation that when the tank is filled to the spring line, the sewage rises through the suction-pipe into the wheel of the centrifugal pump, filling it above its axis so

The sewage is delivered to the tank by three 6-inch lines entering the screening-chamber built out from its end. Two of these sewers deliver at an elevation higher than the top of the tank; the other delivers at the level of the spring line, bringing drainage from cottages on somewhat lower land than that occupied by the main buildings. The screen is movable, so that it may be removed for cleaning when occasion requires. It is sufficiently open to admit all but the larger objects brought in by the sewage to the tank and pump. It is a great advantage of the centrifugal pump that it so beats and trashes the sewage as to reduce nearly all of its solids to atoms. The force-main is an 8-inch spiral, riveted pipe leading from the centrifugal pump to the receiving-well at the absorption-field, 1,550 feet distant. This 8-inch force-main has a continuous rise from the pump to the receiving-well, and the pump has no valve, so that whenever pumping ceases the contents of the receiving-well and force-main flow back into the tank, thus obviating the possibility of freezing.

The field devoted to sewage disposal contains about thirty acres,



that when the pump is started, the driving out of this water is sufficient to exhaust the pump of its air and establish a full suction. The pump is an 8-inch Webber centrifugal, with Westinghouse engines working directly on its main shaft. The suction is 10 inches in diameter and the force main 8 inches. As a provision against a possible failure of the pump, a 6-inch overflow is established at the top of the tank, which delivers into the main brick sewer of the old drainage system, passing near by.

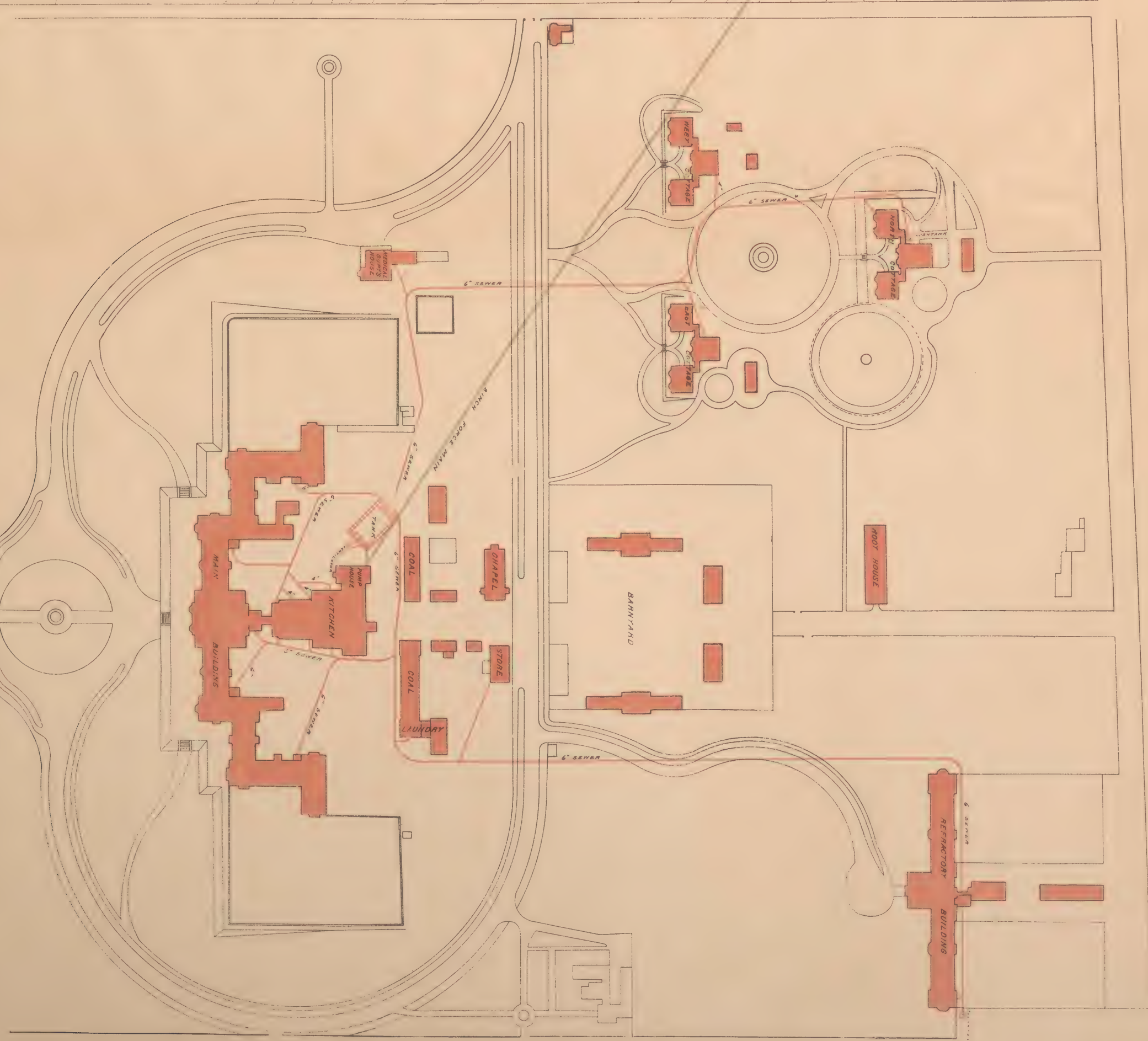
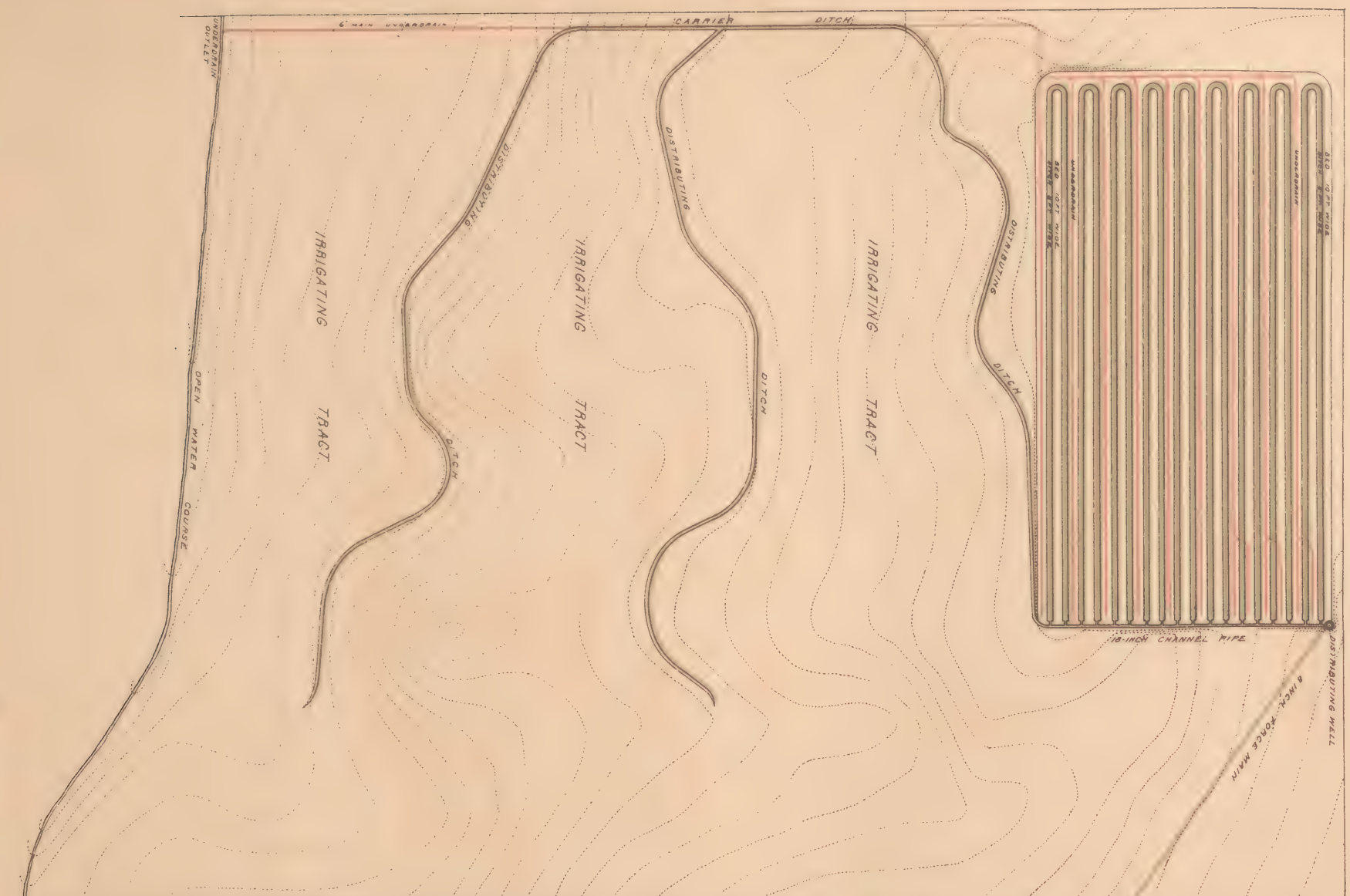
As the tank is underground, artificial ventilation became necessary. This is accomplished through the man-holes. Those at the end farthest from the pump are covered with open gratings. Those at the end nearest to the pump have tight covers. A 10-inch ventilator is taken from the side of each tight man-hole, and is carried to a junction chamber with a 15-inch ventilation-pipe connected with the chimney. There is thus maintained a constant current down through the perforated covers, through the whole length of each section of the tank, and out by the man-hole shafts, which are connected with the chimney.

level at its upper end and sloping gradually for the remainder of the distance to an open water-course.

The level portion of the field is laid off in ditches 8 feet wide at the top, separated by beds 10 feet wide. The ditches are in pairs, returning on each other. Under the bank between each pair is a deep underdrain of agricultural tile. The soil is very light and sandy over the greater part of this tract, and thus far the removal of the purified sewage has been by underground soakage, even the descending effluent, which enters the tiles in the heavier portions in the ground, leaking out through their joints before the outlet is reached. The main outlet from the receiving-well (18-inch channel-pipe) runs across the end of the field, and has a branch to each of the ditches. It has a fall of 1 to 500. At its lower end it delivers into a distributing ditch, which, at its lower end, is connected by a carrier ditch with two other distributing ditches farther down the slope. The main outlet from the receiving-well is made of vitrified 18-inch pipes, split in halves. These half-pipes are connected by concrete channels with the ends of the parallel ditches



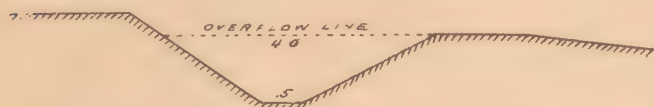




6. LAYOUT OF FARMSTEAD, PLANE SECTION: LOOKING SOUTH  
S. E. WARRING, JR.



(see detail drawings). There are gate-slots between the half-pipes and the concrete branch pieces, furnished with movable gates. By placing and removing these gates, the flow of sewage can be directed at pleasure into all or any of the pairs of parallel ditches. The connection between the concrete branch pieces and the ditches is made with two lengths of vitrified pipe (four feet). As the bottoms of the ditches are all in the same plane, and as the main outlet from the well has a fall, there will be a drop of varying height from the half-pipes into the ditches. At this point, and even where the drop runs out at the lower ditch, the bottom of the ditch is roughly but strongly paved, as shown, to check the flow and prevent the cutting of the bottom at that point. The absorption-ditches are eight feet wide at the top, two feet wide at the bottom and one-and-a-half feet deep. They are separated by beds ten feet wide at the surface. This level area, with its settling-ditches, may be used for intermittent downward filtration, and as



SECTION OF DISTRIBUTING DITCHES

the total capacity of the ditches is equal to twice the capacity of the tank, even were there no immediate filtration, the area is worked in two or three sections alternately. Two or four of these ditches at the lower side of the field may be used, if found necessary, as settling-ditches to deposit heavy matters before delivering the liquid over the surface of the irrigation-tract below. It has been found, however, that the churning of the sewage given by the pump makes such treatment unnecessary.

The capacity of the ditches of the level tract has proved in practice to be so great as to require little use of the distributing ditches in the field below; they are, however, useful for the irrigation of crops. These ditches have a fall of 1 to 500 and are used in the following manner:

If the flow through a distributing ditch is arrested at any point, as it may be by striking a wrought-iron gate into the earth making a dam across it to above the top, the sewage will overflow for a greater or less distance above the dam, according to the volume of

the current. If the dam is placed first at the lower end of the upper distributing ditch, it may overflow, for example, 200 feet above the dam. When the ground to be reached by this overflow has received a sufficient supply of sewage, the dam is placed about 200 feet higher up stream, and the overflow carried over the next section, and then, in like manner, over a third. Should the ground between the two ditches not be able to absorb all the sewage discharged upon it, the overflow will be caught by the lower one, and if its quantity is sufficient can have its distribution regulated by the placing of a dam there, as above.

The main outlet from the well is 400 feet long; the settling ditches have an aggregate length of 3,600 feet; the carrier and distributing ditches have an aggregate length of 3,100 feet; and the tile drains aggregate 6,600 feet. The outlet to the under drainage (six-inch tile) is six feet deep at the end of the upper bed, six and a half feet



SECTION OF CARRIER DITCHES

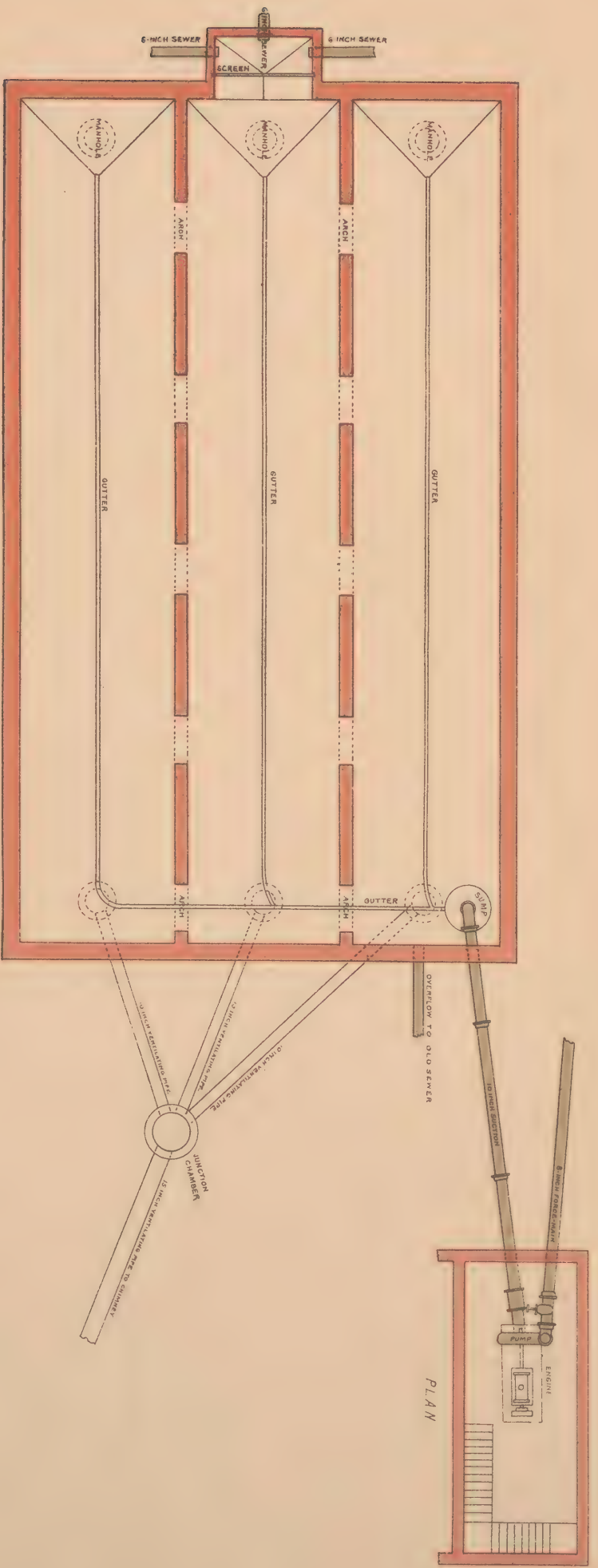
deep at the lower bed. The lateral drains are four-inch tile for the lower half, and three-inch tile for the upper half. The upper ends of these laterals are four feet below the surface of the beds, and they are carried on a true grade to the six-inch outlet pipe. To indicate the care that the successful construction of such work calls for, it may be stated that in the construction of the level (filtration) tract 4,000 stakes were set to both grade and line, 1,000 to line only and 1,000 to grade only.

This system was put in operation in July, 1889, and has worked ever since, in the most satisfactory manner. The Superintendent of the Asylum, wrote as follows (January 2, 1891):

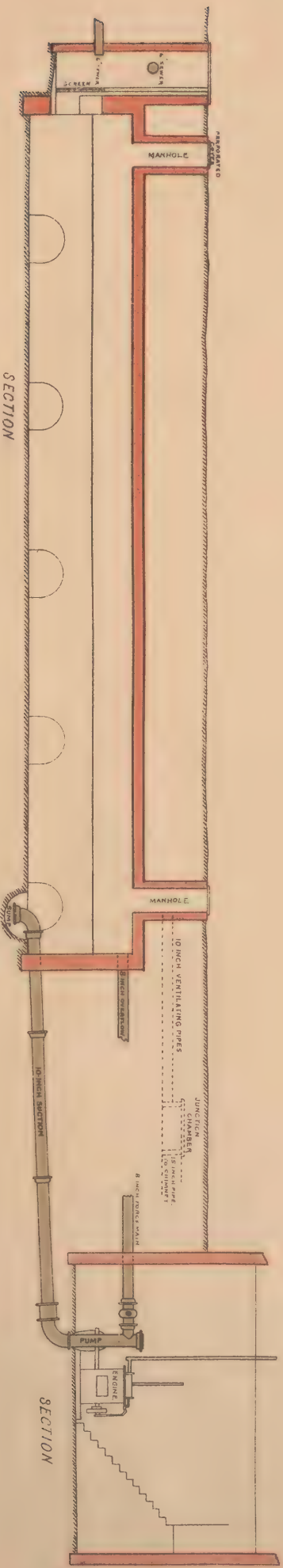
"Our sewage disposal works, put in in the early part of 1889, have been a complete success; neither snow, frost, nor anything else has so far interfered, materially, for a single day with their operation and I consider that the problem of sewage disposal is solved here for all time."



PLAN



SECTION



SECTION

DISPOSAL OF SEWAGE AT THE INSANE ASYLUM : LONDON : CANADA  
G. E. WARING, JR.









